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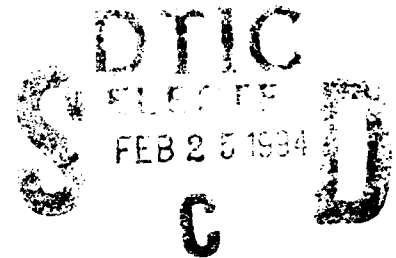
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NRL Memorandum Report 5350

**Radiological and Microwave Protection at NRL
January 1983—December 1983**

J. N. STONE, T. L. JOHNSON, AND R. B. LUERSEN

Health Physics Staff



June 27, 1984



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Washington, D.C.

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RADIOLOGICAL AND MICROWAVE PROTECTION AT NRL

January 1983 — December 1983

INTRODUCTION

This report summarizes the administrative, operation, research, and consultative activities of the Health Physics Staff, Code 6070 for the calendar year 1983.

The Staff has defined each of its primary safety responsibilities and technical functions as programs or projects. The index on page iii of this report identifies each by number and discusses the annual progress of each in a subsequent, appropriately numbered paragraph.

RESPONSIBILITIES

Staff and Sections

The Naval Research Laboratory utilizes over 200 RF-producing devices and 800 sources of ionizing radiation in its research activities. The radiation sources include radioisotopes in microcurie to kilocurie quantities; depleted, normal, and enriched uranium; plutonium; accelerators; a cyclotron; and various types of x-ray machines.

The Health Physics Staff is responsible for establishing the Laboratory-wide safety programs which cover the possession and use of all sources of ionizing and microwave radiation. The Staff also provides the technical monitoring, professional evaluation, and regulatory control activities required to implement the programs.

The Head of the Staff is responsible for halting any hazardous radiological or microwave experiment or operation, in the interest of health or safety, and promptly reporting such incidents to the Commanding Officer. He also acts as the Laboratory's principal representative and advisor on radiological and microwave safety matters.

The Staff is organized as follows:

The Research and Technical Support Section, Code 6072, performs applied research associated with the development and calibration of radiation dosimetry systems required by the Laboratory's radiological safety program, or by other Laboratory or Navy groups. The Section provides consultation and assistance on dosimetry problems to the Staff, Laboratory, and Navy. The Section maintains and calibrates fixed-field radiac instrumentation and sets calibration standards for portable radiation detection equipment used in the radiological safety program.

Manuscript approved March 9, 1984.

The Survey and Analysis Section, Code 6073, performs radiation monitoring of radiofrequency devices, particle accelerators, x-ray equipment, and areas where radioactive material is used or stored. It conducts programs for personnel monitoring, bioassay, radioassay, and radiological safety training and is responsible for the receipt and shipment of radioactive material, radioactive waste disposal, as well as source storage, leak testing, and accountability.

Radiological Committee

The Radiological Committee plays an important role in Staff activities in that a subcommittee of research scientists reviews, on a day-to-day basis, the proposed procurement and use of sources of ionizing radiation. The full Committee, composed of five civilian scientists, the Safety Officer, the Medical Officer, a Naval Officer, and the Head of the Health Physics Staff, advises on radiological safety and serves as a review board for radiological incidents.

Dr. K. W. Marlow, Chairman	Code 6608
Dr. G. Cooperstein	Code 4773
Dr. J. D. Kurfess	Code 4150
Dr. F. K. Lepple	Code 6184
Mr. H. E. Watson	Code 6390
Mr. H. C. Kennedy	Code 2010
Medical Officer	Code 9005
Naval Officer	
Mr. J. N. Stone	Code 6070

Pertinent Regulations

- NRLINST 5400.14J, 1 November 1983, Part III, "Organizational Manual", - description of Code 6070, Health Physics Staff.
- NRLINST 5420.1Q, 13 September 1983, "NRL Boards and Committees", Section 18, Radiological Committee - describes function and responsibilities.
- NRLINST 5101.2E, 4 January 1982, "Responsibilities for Nuclear Safety", - assigns responsibilities and defines nuclear safety program at NRL.
- NRLINST 5100.11D, 2 February 1982, "Radiological Safety Manual", - describes responsibilities and promulgates regulations for radiological protection and control.
- NRLINST 5100.14C, 21 November 1983, "Radiofrequency Safety Program", - protection program for use of non-ionizing radiation-emitting equipment.

ADMINISTRATION

Funding

Overhead (14 people)

<u>FY 1983</u>			<u>FY 1984</u>	
	<u>Budgeted</u>	<u>Expended</u>		<u>Budgeted</u>
Salaries/Wages	488.8K	511.9K	Salaries/Wages	506.6K
Materials/Supplies	29.3	15.9	Materials/Supplies	31.1
Travel	4.0	2.1	Travel	4.7
Depreciation	0.0	1.1	Transportation	0.3
Transportation	0.3	0.0	RCD Services	20.0
RCD Services	15.0	18.6	TID & Library Svcs.	3.3
TID & Library Svcs.	3.0	0.8	Other Div. Svcs./Debits	2.5
Other Div. Svcs/Debits	0.0	5.5	Communications	12.0
Communications	4.0	4.0	Sq. Ft. Charge Debit	77.0
Other Contr. Svcs.	33.0	13.4	Other Cont. Svcs.	19.0
TOTAL	577.4K	573.3K	TOTAL	676.5K

Personnel Actions

R. B. Luersen and K. J. King received letters of appreciation from the Department of Transportation, via the Chief of Naval Research, citing their response to a request from the DOT for assistance in monitoring a shipment of radioactive material in November 1982.

G. F. Harmon was recommended for a QSI in October 1983.

R. N. Davis was promoted to Health Physicist, GS-11, effective 11 December 1983.

A. Stamulis retired on 31 December 1983 after 30 years of government service.

Publications and Presentations

J. N. Stone, T. L. Johnson, and R. B. Luersen, "Radiological and Microwave Protection at NRL, January 1982 - December 1982", NRL Memorandum Report No. 5095, June 1983. FOUO

T. L. Johnson, "Computer Analysis of LiF(TLD-600) Glow Curves to Reduce Errors Due to Fading", presented at the 7th International Solid State Dosimetry Conference, Ottawa, Canada, September 1983. ADA134940

K. J. King and T. L. Johnson, "Dependence of Thermoluminescence Output on Temperature During Irradiation for Several Thermoluminescence Phosphors", NRL Report No. 8761, September 1983.

Travel and Training

K. J. King completed the course, "FORTRAN Programming Fundamentals", on 24-28 January 1983.

E. X. Rank completed the course, "Computer Graphics", on 25-28 January 1983.

T. L. Johnson completed the course, "Effective Motivation through Communication", on 7-9 February 1983.

K. J. King attended the International Beta Dosimetry Symposium sponsored by the Department of Transportation, the Nuclear Regulatory Commission, the Institute of Nuclear Power Operations, and the Health Physics Society, in Gaithersburg, Maryland on 15-17 February 1983.

J. N. Stone attended scheduled meetings of the Armed Forces Radio-biological Research Institute Reactor and Radiation Facility Safety Committee on 24 February, 31 March, 18 May, 17 August, and 9 November 1983.

S. G. Gorbics completed the course, "PASCAL Programming Structure", on 21-24 March 1983.

J. N. Stone completed the course, "Creative Listening", on 14-15 April 1983.

E. X. Rank completed the course, "FORTRAN Planning Fundamentals", on 23-27 May 1983.

T. L. Johnson, R. B. Luersen, K. J. King, and E. X. Rank attended the Annual Health Physics Society meeting held in Baltimore, Maryland during the week of 19-24 June 1983.

P. J. Kasko completed the course, "Letter, Memo, and Report Writing", on 20 June - 1 July 1983.

T. L. Johnson attended the 7th International Solid State Dosimetry Conference in Ottawa, Canada on 26-30 September 1983.

R. B. Luersen attended the course, "Stress Management for Supervisors", on 10-21 November 1983.

K. J. King completed the course, "Technical Writing and Editing", on 21-23 November 1983

R. B. Luersen and K. J. King attended a radiation health administration course conducted by the Radiation Safety Department of NAVMEDCOM at Bethesda, Maryland on 6 December 1983.

Facilities and Equipment

Building 208 — Twelve office and nine laboratory modules on the west end, first floor of Building 208 are occupied by the Staff.

Building 83 — At this facility, the Staff utilizes a 150/300 KV x-ray calibration unit and three Co-60 source wells (96.6 Ci, 3.5 Ci, and 0.6 Ci), for radiac instrument calibration and dosimetry research irradiations. Additional office and laboratory space for the Research and Technical Support Section is located here, also.

Building 89 — This building contains two hot cells which are used for inspecting and leak testing of high level radiation sources and for storage of NRL radioisotopes not being used by authorized custodians. The contaminated protective clothing laundry is located here, as are facilities for the shipment and receipt of radioactive material and rad waste processing and storage.

Organization Chart

1983
HEALTH PHYSICS STAFF

Head

HEALTH PHYSICS STAFF (CODE 6070)

J. N. Stone, (GM-14)

ADMINISTRATIVE SECTION (6071)

(Secretary (Typing))

G. F. Harmon, (GS-6)

RESEARCH AND TECHNICAL
SUPPORT SECTION (6072)

Section Head

T. L. Johnson (GM-14)

Research Physicist

S. G. Gorbics (GM-13)
A. E. Nash (GS-12)

Chemical Engineer

A. Stamulis (GS-12)

SURVEY AND ANALYSIS SECTION
(6073)

Section Head

R. B. Luersen (GM-13)

Health Physicist

K. J. King (GS-12)
W. J. Powers (GS-12)
E. X. Rank (GS-12)
R. N. Davis (GS-11)
J. M. Averitt (GS-7)

Physical Science Technician

E. D. Snyder (GS-11)
P. J. Kasko (GS-9)

STAFF PROGRAMS AND PROJECTS

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- 2.1 Research Projects
- 2.2 Air Pollution Monitoring

- 3.1 Personnel Monitoring
 - 3.1.1 Personnel Accident Dosimetry
 - 3.1.2 Perimeter Radiation Monitoring
- 3.2 Accelerator Monitoring
- 3.3 Radioassay
- 3.4 Bioassay
- 3.5 Radiac Instrumentation
- 3.6 Radiological Safety Training
- 3.7 Radiofrequency Radiation Monitoring
- 3.8 Radiological Monitoring
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- 3.12 Radioactive Source Storage
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- 3.14 Source Accountability

RESEARCH AND TECHNICAL SUPPORT SECTION (6072)

2.1 Research Projects

A. Modifications to Iterative Recursion Unfolding Algorithms to Find More Reasonable Neutron Spectra

One method of determining neutron spectra from sets of detector data makes use of recursion formulas which hopefully find spectra that fit the data more precisely with each iteration from some initial spectrum. For lack of better information, a $1/\text{Energy}$ spectrum is usually assumed with a maximum energy cutoff determined from the detector data or ancillary information. This normally results in unfolded spectra having too many high energy neutrons and a deficiency of neutrons in the intermediate energy region. In order to find a more physically reasonable starting spectrum, we have devised a directed search algorithm called MAXIET which finds a spectrum made up of a thermal component, a $(1/E)^x$ component, and a high energy Maxwellian peak. We have incorporated this algorithm in two recursion unfolding codes, BON and SPUNIT, and have called the new program BUNKI. Details of the MAXIET algorithm will be presented at the annual Health Physics Society Meeting in June 1984. Modifications to the BON and SPUNIT algorithms will be described in a paper to be submitted for publication in the Health Physics Journal, and the BUNKI computer code will be described in an NRL Memorandum Report.

B. Choice of a Response Matrix for Unfolding Neutron Spectra from Bonner Sphere Data

The neutron spectrum unfolded from Bonner sphere data is used throughout the Navy for determining dose equivalent, shielding requirements, and correction factors to be applied to personnel dosimeter readings. The spectrum obtained depends on the unfolding algorithm and the response matrix used; the response matrix being the response of the individual detectors as a function of energy. Because of experimental difficulties in determining the response of the detectors, calculations are usually used. In recent years three new response matrices have been reported in the literature. We therefore began a project to determine the effect of the choice of the response matrix on the spectrum and the integral parameters calculated from the spectrum. The integral parameters of interest were: total fluence, average neutron energy, dose, dose equivalent, quality factor, Navy TLD badge response, cadmium covered TLD badge response, polycarbonate film response, NTA film response, and remmeter instrument response. Our study showed that the parameters such as dose, dose equivalent, average energy, and remmeter response varied up to about $\pm 50\%$ depending on the choice of matrix, while the personnel dosimeter responses varied up to a factor of 10. This indicates the need for a better determination of the detector response matrix, perhaps using Monte Carlo calculations. We will publish details of our study in an NRL Memorandum Report and extract a summary for publication in a professional journal.

C. Calibration of Neutron Dosimeters

Calibration of neutron personnel dosimeters presents considerable difficulty primarily because of interference from neutrons scattered from the walls of the calibration room. Also, the response of the badge is dependent on the position of the badge on the phantom during calibration. Further complications arise because the neutrons which the badge detects do not appear to originate at the badge but at some depth in the phantom. Previously, we have published articles in Health Physics describing the importance of scattered neutrons and how to correct for their presence. We also published an article on the effect of badge position on the detector response. In cooperation with the National Bureau of Standards and the National Naval Medical Center, we performed experiments to determine the effect of the apparent depth of origin of the neutrons in the phantom on the neutron response of two types of albedo dosimeters. We determined that failure to correctly account for the apparent origin of the neutrons can cause calibration errors of 20% or more. After further study, we plan to publish our results.

D. Determination of Scattered Neutron Spectra in Concrete Rooms

We continued work on a project to determine the scattered neutron spectrum in concrete rooms. Knowledge of the spectrum is important in radiation protection monitoring and in the calibration of radiation dosimeters and instruments, which is usually done for convenience in concrete rooms. Dr. Richard McCall of the Stanford Linear Accelerator has agreed to do additional Monte Carlo calculations to test some of the empirical equations which we use to predict the scattered spectrum. In addition, we have written several computer programs to predict the scattered spectrum.

E. X-Ray Spectrometry

Our effort to develop an x-ray spectrometer for pulsed x-ray sources by using thermoluminescence dosimeters and absorption filters was continued. In order to extend the useful energy range to the system to higher energies, three spheres machined from natural uranium were added to the system. This should extend the useful range to approximately 1 MeV. During the year, the system was extensively tested using low-energy γ -rays at the CASINO facility and the AURORA facility, where the system was used to measure low-energy backscatter radiation produced from the interaction of high energy γ -rays in a low-Z absorber. A total of more than 50 spectra have been determined. As mentioned in last year's report, attempts to calculate response functions for the spheres have been disappointing. The Defense Nuclear Agency has agreed to do some calculations for us using the SANDYL transport code on a large class VI computer. This is the only remaining problem to be solved in order to have a workable system for routine dosimetry applications. The required thermoluminescence dosimetry techniques were established years ago and the mathematical problem of unfolding the spectrum from the data has been solved by YOGI, an iterative perturbation method of solving simultaneous equations which we originally developed to unfold neutron spectra from "Bonner sphere" data.

2.2 Air Pollution Monitoring

The air monitoring station functioned normally throughout the year gathering data on the concentrations of ozone, sulphur dioxide, nitric oxide, nitrogen dioxide, other nitrogen oxides, methane, total hydrocarbons, and carbon monoxide. In addition, air temperature, relative humidity, and wind speed and direction were also measured. The data gathered was disseminated to various groups, including the Environmental Protection Agency. The monthly concentrations of the various pollutants are given in Table 1. There are no significant changes in the concentrations shown in Table 1 from those of previous years. The air monitoring station was shut down on 1 October and the experiment transferred to the Chemistry Division.

TABLE 1								
MONTHLY AND YEARLY AVERAGES OF AIR POLLUTANTS (IN ppmv) DURING 1983								
	O ₃	SO ₂	THC	CH ₄	RHC	CO	NO	NO ₂
Jan	0.011	0.017	2.16	1.83	0.34	1.31	0.034	0.021
Feb	0.024	0.015	2.16	1.99	0.25	0.92	0.042	0.030
Mar	0.039	0.009	2.16	1.79	0.68	--	0.017	0.021
Apr	0.034	0.009	1.99	1.39	0.59	0.81	0.019	0.018
May	0.035	0.007	--	--	--	--	0.010	0.018
Jun	0.031	0.008	--	--	--	--	0.017	0.018
Jul	0.047	0.010	2.51	1.97	0.59	1.08	0.017	0.012
Aug	0.039	0.008	2.60	1.89	0.75	1.06	0.019	0.017
Sep	0.028	0.007	2.62	2.51	0.18	0.90	0.019	0.022
Yearly Average	0.032	0.010	2.31	1.91	0.48	1.00	0.022	0.020

SURVEY AND ANALYSIS SECTION (6073)

3.1 Personnel Monitoring

The Personnel Monitoring Program is established for the purpose of evaluating radiation exposures to personnel working in a wide variety of radiation environments at NRL. The program also provides important information for controlling exposures to radiation and determining the overall effectiveness of our Radiological Safety Program.

The needs of the Program are set forth in both federal and Navy regulations. Title 10, CFR, Part 20.202, and NAVMED P-5055, Radiation Health Protection Manual, require the Laboratory to provide personnel monitoring devices to individuals working with sources of ionizing radiation.

During 1983, the Staff used thermoluminescence dosimeters (TLD) for determining occupational radiation exposures to Laboratory personnel. The TLDs are evaluated monthly for the Cyclotron, Linac, High Level Radiation Laboratory, and our Staff. The rest of the dosimeters (about 330) are processed on a quarterly schedule. We maintain a shorter processing schedule for the aforementioned facilities because over 90% of our occupational exposures occur at them. A monthly determination permits management of each facility more latitude in adjusting work schedules and allows our Staff to change the amount of surveillance in order to keep exposures as low as possible.

The results of the personnel monitoring program for 1983 are as follows:

Personnel receiving	no measurable exposure	700
"	"	measurable exposure < 0.1 Rem	34
"	"	0.1 to 0.25 Rem	3
"	"	0.25 to 0.5 Rem	8
"	"	0.5 to 0.75 Rem	1
"	"	measurable exposure > 0.75 Rem	0

During 1983, no employee exceeded the exposure limits of 1.25 Rem per quarter as described in 10 CFR, Part 20.101, and NAVMED P-5055, Ch. 4-3. All exposures greater than 0.010 Rem are considered measurable.

The Laboratory has made application for accreditation of its personnel dosimetry program to the National Voluntary Laboratory Accreditation Program (NVLAP). The administration of NVLAP is carried out by the National Bureau of Standards. The laboratory accreditation program for personnel dosimetry processors was established in response to a request from the Nuclear Regulatory Commission (NRC). The purpose of NVLAP is to: (1) improve the accuracy of reported dose measurements made by personnel dosimetry processors and, (2) to give recognition to competent processors. Proposed rules requiring NVLAP accreditation as a condition of NRC licenses have been presented in the Federal

Register for comment. NRC proposes implementation of the testing requirement for February 1986. According to the NRC, this date will allow dosimetry processors ample opportunity to participate in the performance testing by NVLAP.

As a result of an inspection audit by NAVMED at the NRL Medical Clinic, the Staff will need to make some significant changes in its reporting procedures for personnel monitoring. In order to accomplish these changes without creating excessive work loads for some members of the Staff, we will completely rewrite our computer program for dosimetry. At present, the program is being produced on the computer at the Comptroller's Office and is very limited in scope. The new program will be written for use on the DEC-10 and will produce all of the reports and records required by Navy regulations (NAVMED P-5055).

3.1.1 Personnel Accident Dosimetry

The Personnel Accident Dosimetry Project provides an accident dosimeter for individuals who do not work with radioactive materials or who, in the course of their work, do not enter radiation areas. In the case of radiation workers, this Project supplements the regular Personnel Monitoring Program.

The present accident dosimeter is a single teflon disc containing a thermoluminescent phosphor (LiF). The disc is laminated into the NRL security ID badge and is positioned behind the photo of the employee. When employees, who were issued this dosimeter, complete their employment at NRL, their security badges are returned to the Staff for filing. Should any of these employees, at a later date, claim that they received a significant exposure of radiation while working at NRL, we can pull their badge from the file and evaluate the dosimeter.

3.1.2 Perimeter Radiation Monitoring

The Perimeter Radiation Monitoring Project is designed to accomplish the following objectives:

- (1) To measure radiation levels at the perimeter of NRL and external areas of buildings within the perimeter.
 - (2) To determine if NRL sources are contributing to fence line radiation levels, identify these sources; and reduce levels, if necessary.
 - (3) To develop instrumentation and techniques sufficiently sensitive and reliable to accurately measure environmental levels of radiation.
 - (4) To show compliance with applicable federal and Navy regulations.
- The Fence Line Monitoring Project has undergone several changes during the past year. The Project was expanded to include thirteen new monitoring

stations which were carefully chosen to monitor sites where the potential for higher than normal backgrounds could exist. A study of several calibration procedures was carried out in order to find the one which will give us the most accurate data. The procedure finally selected is used for our environmental and our personnel dosimetry.

Environmental air samples were collected from a station on the roof of Building 208 throughout the year. The samples were collected on 8" x 10" Whatman glass microfiber filters at an average air flow of 8.5×10^5 SCF per month. The samples were counted for 1000 minutes on our solid state (GeLi) detector which was calibrated using an NBS-traceable liquid calibration standard. Two isotopes which showed up consistently were Be-7 and Cs-137. The Be-7 is produced by interactions of cosmic rays with atmospheric nuclides, while the Cs-137 is a fission product remnant of the atmospheric nuclear detonations set off by the Chinese around October of 1980. The average concentrations of each of these isotopes for the year were:

Be-7 8.7×10^{-14} $\mu\text{Ci/cc}$

Cs-137 5.9×10^{-16} $\mu\text{Ci/cc}$

3.2 Accelerator Monitoring

Accelerator monitoring is the detection and measurement of a specific radiation or a group of radiations in and around the various accelerators at NRL. It involves the use of standard radiation detection equipment which may be modified to make as convenient as possible the particular measurement required.

Although particle accelerators do not come directly under NRC regulatory control, the fact that NRL operates under a byproduct license necessitates a monitoring program. According to Title 10, CFR, Part 20.101, other sources of radiation in the licensee's possession must be considered in exposure limits governing radiation workers.

Personnel working with accelerators necessarily receive some exposure to radiation. Hopefully, frequent radiation surveys and good operation practices will hold these exposures well below the approved limit. However, chances to receive larger amounts do exist and, thus, it is necessary to maintain an extensive monitoring program to prevent this possibility.

Ideally, an effective program should provide the maximum amount of radiation safety while allowing the various facilities to function at their maximum capabilities with a minimum amount of interference. During 1983, a rigorous health physics surveillance program was maintained at all of NRL's accelerators. The following summarizes some of the highlights at the various facilities.

A. Cyclotron

Routine surveillance at the Cyclotron indicated that activation of the machine components continues to create high radiation levels, while contamination levels remain fairly low. The major maintenance problem at this facility involves the pull-back of the RF resonator tank. These pull-backs require coverage in the form of smear surveys, dose rate surveys, and, usually, decisions as to what parts can be machined or worked on in the shops, or what restrictions must be imposed before they can be worked on. Although these operations are routine, they are very time consuming.

During the year, work was completed on all the hoods used by NIH in their various syntheses. Air flow into the hoods has been checked for all possible combinations of the four hoods being opened or closed and found to be sufficient.

A potentially serious incident was avoided at the Cyclotron facility when some stainless steel tubing broke during the transfer of F-18 from the main vault into the Room 1 hoods. The tubing carrying the F-18 broke because a valve in the line was not fastened to any supporting structure. As a result, the tubing was taking all the torque when the valve was opened or closed. We were fortunate that the line broke when the valve was in a closed position. If it had broken when the valve was open, about half a Curie of F-18 could have been released into the room. To prevent a recurrence of a similar incident, all valves in Room 1 that carry radioactive fluorine and are opened or closed during the synthesis were bolted to support plates, and the support plates and valves were then anchored inside the hood.

Because of this happenstance, a thorough review of the NIH synthesis and procedures was made. Our findings indicated that the synthesis was substantially different from the originally approved set-up and that the difference was due to a gradual process of evolution. To correct this problem, new schematics and procedures were written by NIH and these were subsequently approved by the Radiological Committee.

B. Linac

During the year, the Linac performed routine irradiations. Consequently, our efforts for this facility were mostly routine. Facility personnel made a serious effort to clean up old beam-line components that were being stored at the facility. Smear and dose surveys of the hundred-odd pieces showed that only a half-dozen or so needed to be discarded as rad waste. The rest showed no removable surface contamination and no activation levels greater than 0.5 mR/hr at the surface.

C. Beam Dynamics

Plans for the 50 MeV Betatron have progressed to the point that a home must be found for the machine. Present plans call for putting it in

Room 3 at the Cyclotron and moving the Induction Linac, which is already in the room, to some other location. One of the problems of finding rooms for all the machines is to provide adequate radiation shielding; consequently, a fair amount of time was spent during the year calculating how much shielding would be necessary for various combinations and permutations of machines and rooms.

3.3 Radioassay

The Radioassay Program is designed to furnish, for the Staff, the amount of radioactive material and/or contamination in any sample submitted for analysis. The Program is capable of performing both qualitative and quantitative analyses on all samples.

The need and significance of the program is generated by Title 10, CFR, Part 20. In general, the regulations require all licensees to determine the radioactive content of all gases, liquids, and solids prior to discharging them to the environment.

During 1983, approximately 1400 smear samples were analyzed under this Program. In addition, some 280 liquid and air samples were analyzed using the multi-channel analyzer and liquid scintillation spectrometer. The majority of samples collected were from the High Level Radiation Laboratory, Cyclotron, Linac, and the Air Monitoring Station.

New calibration standards, with activities traceable to NBS, were received and several sources were fabricated to match the configuration of our counting samples. The new sources were used to complete the calibration of our solid state (GeLi) detector and multichannel analyzer. The new efficiencies obtained during calibration were used to update our computer programs for the analyzer.

Several changes to our equipment occurred during the year. The modular components required to renovate our liquid scintillation counter were received and installed into the system. Also, the sample changer was removed from the old system and modified to work with the new system. By utilizing the modular equipment, we were able to replace the old liquid scintillation system for about a third of the cost of a new scintillation counter while maintaining the same reliability.

During the year, we purchased a Tracor Northern, TN-7200, multichannel analyzer. Prior to making the purchase, we reviewed most of the analyzers available and decided that the Tracor was far superior to the others in terms of portability, options, accessories, and price. The new system will be used by the Research and Technical Support Section to analyze neutron spectra and as a backup to our computerized multichannel analyzer.

3.4 Bioassay

The Bioassay Program is basically the examination of some part of the body or its products.

The need for the Bioassay Program is generated by Title 10, CFR, Part 20.108. In general, this regulation requires all licensees to determine the extent of an individual's exposure to concentrations of radioactive material. It further directs the licensee to make available to the individual appropriate bioassay service.

During the year, 23 individuals were sent to the National Institute of Health in Bethesda, Maryland, for whole body counts. The results of these counts indicated that all individuals were well below the maximum permissible body burdens for all radionuclides.

A urinalysis was conducted whenever an individual was working with radioactive materials that were easily taken up by the body or in an area where airborne concentrations were likely. The selection of individuals for urinalysis is determined by the Staff's health physicists. The levels of internal radiation detected in all urine samples (26) during 1983 were below the maximum permissible body burdens.

3.5 Radiac Instrumentation

The instrumentation provided by this Program is used to measure the absorbed dose and exposure rates of various types of ionizing radiation in any area that may be occupied. In addition to providing instruments, this program assures that the various instruments are in proper working condition and are calibrated. Also, this Program makes every attempt to anticipate the needs of the Staff before the need materializes.

During 1983, all portable instruments were serviced and calibrated every nine weeks. Replacement of our old portable instruments (greater than 20 years service) was begun in 1983; we expect the replacement program to take 5 years as we replace 20% of the instruments each year.

3.6 Radiological Safety Training

This Program is designed to provide adequate training in Radiological Safety to: (1) all personnel involved in emergency response at NRL; (2) scientists and technicians at NRL whose duties involve the handling or use of radioactive sources; and (3) outside activities, as requested, and as time permits.

During 1983, routine indoctrination for all new employees was performed on a monthly basis.

A training lecture on radiation safety was presented to new supervisors. This lecture strongly emphasized the regulatory aspect of radiation safety. In particular, all of the forms which are used by the Health Physics Staff to ensure compliance with Navy and other regulations were reviewed.

A lecture was also presented to high school students who worked at NRL during the year. This lecture stresses that radiation is an unavoidable and normal part of life and that radiation risks must be balanced against the benefits which radiation can provide.

Training lectures were completed in early 1983 for firemen stationed at NRL. The lectures covered topics relating to fighting a fire in a radiation environment. The use of radiation instruments was covered, as well as the short- and long-term effects of radiation.

A lecture and training guide on the effect of radiation during pregnancy is being prepared. At present, we are using NRC Regulatory Guide 8.13, "Instructions Concerning Prenatal Radiation Exposure", as our written document. Hopefully, a better guide can be prepared which is more complete, deals with radiation in a little better perspective, and does not create a great deal of stress. The slides for this lecture have been purchased and reviewed and most of the relevant papers and reviews have been obtained.

3.7 Radiofrequency Radiation Monitoring

This Program evaluates and controls personnel exposure hazards associated with the operation, modification, or repair of radiofrequency (RF)-emitting equipment.

Experiments have shown that short exposures to RF and microwave radiation at certain power levels will cause significant damage in human tissue. To assure that these hazards are acknowledged, the Navy has established RF safety procedures and exposure limits designed to prevent hazardous exposures at any power level and/or time interval. This Program assures that NRL's RF and microwave equipment is operated in accordance with Navy regulations.

Surveys of all registered microwave ovens at NRL were conducted every three months during 1983. None of the surveys detected an oven leaking in excess of the NAVMED limit of 5 mW/cm².

Routine surveys of RF-emitting equipment located throughout NRL continued during 1983. Surveys were conducted only on equipment capable of producing hazardous levels of power (>10 mW/cm²). Findings of all the surveys and, if necessary, the Staff's recommendations were presented in a written report to the operators of the equipment.

NRLINST 5100.14C was rewritten to reflect the recent changes in the new ANSI Standard (C95.1). The new standard establishes exposure limits for radiofrequency electromagnetic radiation in the 300 KHz to 100 GHz range.

A computer program was developed that contains all of the individuals who are on the microwave physical and eye examination list. This program has the capability of adding or deleting individuals from the list, as well as editing the data presently being stored for each individual. The program keeps the list of microwave workers current by generating a computerized letter to each code that maintains microwave equipment.

3.8. Radiological Monitoring

Radiological monitoring is the means by which radiation and/or contamination hazards associated with the production and use of radioactive material, or the operation of ionizing radiation-producing equipment, are detected, evaluated, and controlled. Progress summary details for this Program are contained in the following three projects.

3.8.1 X-Ray Monitoring

The X-Ray Monitoring Project evaluates and controls the radiation hazards associated with the operation of x-ray equipment by means of routine and special surveys.

Approximately fifty routine surveys of diffraction units, electron microscopes, irradiators, pulsed x-ray sources, and spectrometers found no hazardous radiation levels in occupied areas.

The Gamble II machine was modified to include an inductive energy storage system on the diode end of the transmission line. This system raises the discharge potential of the machine from about 1.2 MeV up to 2 or 3 MeV. Surveys have been made with this system used as both an electron beam and an ion source. Exposures at 2 meters from the diode were found to be 100 to 300 mR per shot. Long-term measurements in office areas around the Gamble II machine failed to show radiation levels above background.

An ion implantation unit in Building 208 was surveyed and showed significant leakage in some areas around the machine. Although background levels were detected at the operator's console and desk, recommendations were made to install lead shielding in order to reduce leakage. Additional surveys conducted after the shielding was installed detected only background levels.

Code 6840 has installed a Gyrokystron beam tester on the third floor of Building 208. The Staff performed surveys on this device and found significant x-ray production at 60 KV potential. At our request, lead shielding was placed around the collector of the device to eliminate possible personnel exposure. Maximum unshielded radiation levels were 70 mR/hr at contact and 1 mR/hr at 3 feet. With the shielding, levels were reduced to background.

Surveys with TLD badges were made on pulsed electron beam machines in Buildings 101 and A68 throughout the year. The Gamble machines were used by NRL personnel for ion beam and electron beam transport research experiments, but were inactive for periods during which room renovations and machine repairs were being made. No exposures in occupied areas around the machines were observed.

Code 4760 is planning to expand the scope of their work on the Pulserad machine in Building 101 by attempting to obtain funding for a 5 mw, 100 K amp machine to be installed in the present Metals Storage Area in Building 71. This machine would attempt to propagate electron beams over path lengths of 10 to 20 meters. Our preliminary calculations indicate a shielding requirement of 3 to 4 feet of concrete to keep radiation levels down to less than 10 mR/week under the maximum operating frequency planned.

3.8.2 High Level Radiation Laboratory Monitoring

HLRL monitoring assures that the radiation and contamination hazards associated with the handling and testing of large quantities of radioactive material at this facility receive comprehensive radiological safety evaluation and control.

Activity of a radiological nature continues to be minimal at this facility. The only active programs involving the use of radioactive materials are the testing of specimens belonging to one of the experiments from the Buffalo reactor, and the transfer of specimens to ORNL for testing.

Extensive cleanup of the Warm Work Area occurred in January. Excess tool, equipment, and "junk" were collected and prepared for disposal as rad waste. Three drums of waste were packed for disposal. Air samples were taken during cleanup and waste packing. Significant air activity was generated during the packing; maximum activity found was 10^{-9} $\mu\text{Ci/cc}$. The isotopes present were Mn-54, Co-60, and Cs-137. Airborne activity was still one or more orders of magnitude below the MPC's for a 40-hour work week. Personnel compacting the waste used supplied air hoods and full protective clothing to avoid unnecessary exposure to radioactive dust.

Filters in both Bank 1 and Bank 2 were replaced during the year by personnel from the Heating and AC Shop. Air activity in the filter bank was 6×10^{-12} $\mu\text{Ci/cc}$ during the change. The workmen installing the filters wore half-face respirators.

Exhaust stack air activities measured during the year were generally in the range of 10^{-15} to 10^{-14} $\mu\text{Ci/cc}$ with Mn-54 and Co-60 occasionally being found during gamma-spectroscopy analysis. Warm area constant air monitor samples were less than 6×10^{-14} $\mu\text{Ci/cc}$ with many in the 5×10^{-15} $\mu\text{Ci/cc}$ range.

3.8.3 General Area Monitoring

General area monitoring provides radiological services to facilities having Van de Graaff accelerators operating at voltages of less than 5 MeV, areas using large quantities of radioactive materials on an infrequent or inherently safe basis, and/or areas in which a number of sources with limited activities are used or stored.

A. RSRs

Of the 84 Requests for Radiological Safety Review (RSR) that were received and processed, 50 requested changes in source custodian/location, 12 requested the purchase of new sources/equipment, 18 were for irradiation services, and 4 were for the disposal of unwanted material.

B. CBD Hypervelocity Range Tests

Four high velocity impact tests involving depleted uranium were conducted at the CBD Hypervelocity Range. The detonation of high explosives associated with the targets spread depleted uranium dust throughout the evacuated, enclosed portions of the target chamber and blast tank. NRL and contractor personnel entered the target chamber and x-ray film room after each test to clean up debris and to remove x-ray film.

Radiation exposures were minimal; surveys showed radiation levels to be generally less than 0.1 mR/hr except at locations near uranium-bearing debris. The target had maximum radiation levels of 0.5 mR/hr at contact.

The primary radiological hazard was ingested or inhaled uranium dust. All personnel working in areas with significant airborne dust wore full-face respirators and full anti-c clothing. Air samples were taken on an almost continuous basis in contaminated areas in order to document personnel exposure to uranium. Urine samples were taken to evaluate retained uranium in the body.

Air activity in the target chamber, x-ray room, and blast tank exceeded the MPC of 1×10^{-10} $\mu\text{Ci/cc}$ during entry and cleanup on the first day after each test. Maximum air activities were near 10^{-9} $\mu\text{Ci/cc}$; however, the weekly integrated exposure of personnel did not exceed that which would have been produced during 40 hours of work at maximum permissible concentrations. In addition, no allowance for the use of respirators was made when calculating exposure to airborne uranium.

No persons working on these tests was exposed to more than 25% of the maximum allowed exposure to airborne uranium over the 3 months in which testing and cleanup were done. Preliminary urinalysis results show no detectable increases in urine activity.

Waste generated in these tests was packed in 55-gallon drums and will be returned to the sponsor.

3.9 Radioactive Material Shipment/Receipt

The movement of radioactive material is authorized and controlled to assure that shipments are packaged and labelled properly; that receipts are monitored, tagged, and delivered promptly; and that intra-Laboratory transfers are accomplished safely.

Twenty-seven incoming shipments, totalling 40 Curies of various isotopes, and 17 outgoing shipments, totalling 26 Curies of various isotopes and 138 grams of depleted uranium, were handled without problem. In addition, about 170 samples, totalling 3.1 Curies, were monitored and released to NIH at the Cyclotron for shipment to their facility.

3.10 Radioactive Waste Disposal

This Program provides for the collection, packaging, and disposal of solid waste and the controlled release of liquid waste to the sanitary sewer. Due to the limited amount of rad waste generated in 1983, there were no shipments of rad waste during the year. Several drums and boxes are scheduled for shipment in early 1984. There were no releases to the sanitary sewers from the Building 71 hot cells or the hold-up tanks at Building 89.

3.11 Radioactive Decontamination

This Program provides for the control and removal of contamination created by the use of radioactive materials at the Laboratory.

During the year, decontamination efforts were limited to those normally required by routine operations.

3.12 Radioactive Source Storage

3.13 Radioactive Source Leak Testing

These Programs assure that sealed sources held under USNRC licenses are leak tested, as required, and that unused radioactive materials are stored safely.

Completion of 252 source leak tests found none to be leaking.

There were 126 sources in storage at the end of the year. All of these sources are stored in Building 89.

3.14 Source Accountability

Source accountability is maintained by means of quarterly inventories conducted by source custodians and cognizant health physicists utilizing computer-produced listings of source location and description.

Quarterly source inventories were completed as scheduled and, with one exception, all sources were located. The exception being a gas chromatograph containing two H-3 sources of about 170 μ Ci each. The instrument was declared surplus and transferred to the Defense Logistics Disposal Facility at Brandywine, Maryland without our required approvals and inspection. Discussions with personnel at the disposal site led to the conclusion that the chromatograph is probably somewhere in the middle of a pile of scrap electronic equipment. We are presently awaiting a call from the disposal site to let us know when the pile of scrap will be loaded so that a member of our Staff can attempt to locate the device and remove the sources.

At the end of the year, 117 custodians held 842 sources — 510 on Materials License No. 8-3193-02, and 159 on Source Material License No. SMB-448. Also among their totals were 44 radium sources and 129 radiation-producing machines.

A new Source Accountability Program for use on the DEC-10 was written and debugged. The new Program, which utilizes local terminals, will provide the Staff several pertinent reports on demand. Also, the Staff can edit the Program on a daily basis; consequently, any requested report will reflect the latest data available. An added feature of the new Program is that any changes to the computer program can be made immediately by the Staff rather than waiting several months for the RCD programmer to do it.